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THE FIRST FAUNA OF THE EARTH.

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One of the most interesting questions with which the geologist has to deal is the age of the earth. There is, however, no subject that is wrapped in more profound obscurity, and yet probably none to which more attention has been given. Perhaps it may never be settled positively; but, as years roll on, and more and more facts come to light, speculations may be made with a greater amount of certainty. It may be possible, in the future, to say approximately how many centuries have elapsed since the earth assumed its present form, but, of course, it can be *only* approximate. Estimates vary now between one hundred million and five hundred million years, since the first rocks were laid down.

While this matter still remains uncertain, there is another which was formerly, and still is, in much the same state. It is the beginning of life upon the earth. Geology is a young science, but her sister, Paleöntology, is younger. Both are taking rapid strides forward, and, working hand in hand, they will eventually be able to tell us much of interest about this globe of ours.

The steps required to bring any science from a state of chaos to one at all approaching precision are innumerable. The records of these steps are mostly buried in official reports of governmental surveys, technical periodicals, or in the ponderous proceedings of learned societies. It is especially so with geology. To those familiar with these records there is much to excite wonder and surprise. There are romances hidden in them. There are wordy wars and fierce intellectual combats. There are charges and counter-charges. There are victories or defeats, equal in one sense to those of Austerlitz or Waterloo. It needs but the mention of the Darwinian combat to call one of these wars to mind. Another, but more obscure one, relates to the first forms of life upon the earth, and it is the intention here to call attention to this.

It is only a little over one hundred years since the first scientific observations upon stratified rocks and fossils were recorded. It was natural that, in the early part of this century, the crudest ideas should prevail regarding these subjects. The origin and cause of stratification were unknown. The nature of fossils and their value as indices to pre-existing forms of the animal or vegetable kingdom had not been thought of. Some few of the shrewder heads, Rafinesque among them, had begun to see the value of fossils as early as 1818, but the general opinion was probably that expressed by Amos Eaton in that year in the first edition of his "Index to the Geology of the Northern States." Here he announced it as his belief that the land inhabited by the first human beings was supported by two segments of granite, beneath which was an immense sea. The North American Continent, he said, "may now be supported in the same way: and the meeting of the edges of the segments may be near the granitic ridge which extends from Georgia to the Frigid Zone." He further supposed that, during the Deluge, all animals, except those preserved by Noah, were destroyed, and the petrified remains we now find are some of the species overwhelmed by that catastrophe. "Noah," said he, "took into the Ark the land animals of the island or continent whereon he resided. This is now covered with the ocean, and we know nothing of the remains to be found there." He rightly believed it would have been most interesting to have some account of the researches of the patriarch and his family "among the recent ruins of former grandeur. But we have no account," he says, "of any discoveries nor of any attempts to search out their former inhabitants. It was doubtless well known to Noah that not one foot of the ancient continent remained above water." That Prof. Eaton did not long retain his belief in the theory advanced, seems evident from the fact that these speculations are omitted from the second edition of the "Index," published in 1820. They have since faded from the public mind, and have taken their place with the still older ideas that fossils were fallen stars and Belemnites were solidified thunderbolts.

The rapid advance in public opinion as to the value of geological studies is shown by the organization of numerous State surveys. The first of these was of North Carolina. Prof. Olmstead reported on its geology as early as 1823, and this survey was followed by one in Massachusetts, where Hitchcock reported in 1831. Between that date and 1838, the States of Maine, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, Georgia, Tennessee, Kentucky, Ohio, Indiana and Michigan had published reports. The general government, too, had sent expeditions to the northwest, and had published the results. It is true many of the State surveys ceased after the issuance of a few documents, but their existence, even for a short time, was evidence of the belief in their value. Some of the States organized second surveys at a later date, and published numerous volumes. Among these are especially to be mentioned New Jersey, Pennsylvania, Kentucky, Ohio and Indiana. Of all the States mentioned, New York possessed the greatest vitality; and, while there have been changes in it as in others, the work there has been more nearly continuous than in any other. Remarkable as it may seem, the present honored head of the survey, the veteran Prof. James Hall, was one of the original corps in 1837.

Although designed primarily to report upon the general economic and mineral resources of the respective States, these surveys necessarily became concerned with other work. It was soon found that in order to intelligently describe the rocky strata, it was essential to give the rocks distinct names. These were, at first, taken from mineralogical characters, and such terms as "metalliferous" and "geodiferous limerock" were the result. Or the name was given from some special physical aspect, and then "cliff limestone" and "marlite" were applied. Finally, however, the plan of giving the formations the names of localities where the rocks were either best developed or had been first observed was adopted, and then such names as "Potsdam," "Trenton" and "Niagara" were used.

Another matter, too, which soon became one of the prominent features of the geologists' work, was the study of the organic contents of the rocks. It was early observed that certain species occurred constantly in certain strata, while above or below them, other and different species were found. When once this fact was established, geologists availed themselves of it to place in one horizon, or to consider as of one age, the beds containing the same species of fossils, even when found in distant parts of the country.

The lack of any method of coöperation between the members of the various State surveys, led to great diversity of nomenclature. In New Jersey, Pennsylvania and Virginia, the formations were known by numbers; in Ohio and Indiana they received names from lithological features, while in New York it early became the plan to give the various formations names of places where they were best exposed. Perhaps it is to be considered fortunate for the science that so many of the State surveys ceased early, else the nomenclature might have been as varied as the different States had rocks. It was the vitality or persistence of the New York Survey that enabled her geologists to establish a system of names for almost the whole North American Continent, so far, at least, as the rocks lying within her borders were capable of doing. Thus the "New York System" became a standard to which was referred strata of similar character occurring in all parts of the country.

None of the rocks of New York are of later age than the Devonian. Most of them, indeed, are far older, and so complete is the series that there is no formation from the Archean or metamorphic rocks to the latest Devonian lacking. A portion of the scheme, as finally adopted, is as follows:

Upper Silurian	Lower Helderberg
	Onondaga
	Niagara
	Clinton
	Medina
	Oneida
Lower Silurian	Hudson River
	Utica
	Trenton
	Chazy
	Calciferous
	Potsdam
Archean	

All of the formations lying above the Archean are stratified, and contain a greater or lesser number of fossils. Each formation is generally separated from the one above and below by some unconformity, indicating a time during which deposition was not going on. These time breaks are also characterized by changes in the organic forms. In other localities than New York, these breaks in sedimentation and life do not always occur. Sometimes the change in physical features is so gradual that it is impossible to say where one group ends and the next one begins. Fossils, too, pass from one into the other with little or no change. In all such cases there is great difficulty in drawing any line of demarkation, but, in general, it can be readily done.

In the early years of the existence of the New York Survey, Dr. E. Emmons noted the occurrence of a sandstone in the northern part of the State, lying directly upon the metamorphic or igneous rocks. From its proximity to the town of Potsdam, he gave it the name of "Potsdam sandstone." Its position in relation to metamorphic rocks caused it to be considered the oldest formation in the State, and the organic remains found in it were regarded as representing the earliest life on the globe. These remains were scanty, consisting chiefly of a species of *Lingula* as then understood (Fig. 1), and of some straight, vertical tubes, at first regarded as seaweeds, but later on as the burrows of marine worms (Fig. 2).

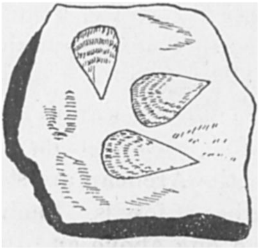

Fig. 1. *Lingula antiqua.* The species for a long time supposed to be the oldest fossil on the globe.

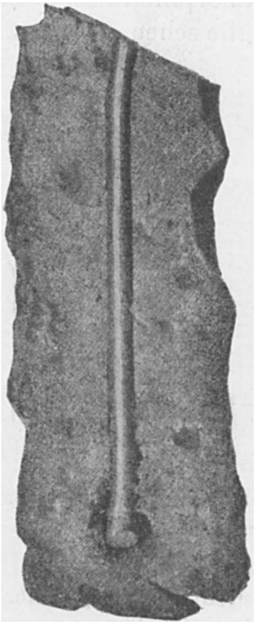

Fig. 2. *Scolithus.* A worm boring.

Continuing in western Massachusetts the studies begun in northern New York, Dr. Emmons, in 1842, announced his belief that the Potsdam sandstone was not the oldest, stratified, fossil-bearing rock in North America, but lying beneath it, and therefore older than it, was a great series of sedimentary rocks for which he proposed the name " Taconic." It was not, however, until two years later, in 1844, that he described some fossils from this older series. Among these were two trilobites, and it is probable that more has been written regarding these two fossils than almost any others in the world, and in Figure 3 is shown one of them. These specimens were, of course, regarded with great interest, as they carried life on the globe further back in time than had ever before been supposed possible. The evidence adduced by Dr. Emmons as to their great age was not, however, accepted by the geological world. Geologists were loath to believe that so highly organized an animal could have existed at so early a period. Some believed the rocks containing the fossils were younger than the Potsdam, instead of being older, considering that even if they were really lying underneath the Potsdam sandstone, that it was by reason of a fault or dislocation which had reversed the original position of the two formations. In fact, the existence of the possibility of a series of *sedimentary* deposits below the Potsdam was denied, although this has long since been admitted. Yet long and bitter has been the controversy over this Taconic system; and while it is now known that Emmons included rocks of various ages in his new terrane, no one disputes the fact that he was the first to record evidence of the existence of animal forms in what are, at present, regarded as the oldest fossil-bearing rocks of the globe.

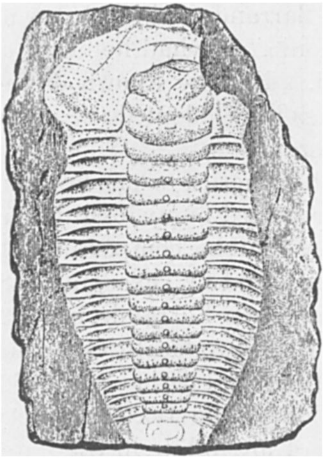

Fig. 3. *Ptychoparia* (*Atops*); *trilineata*. The first trilobite known from the Cambrian rocks.

Previous to Emmons's work in North America, Sedgwick and Murchison had been studying the formations of England and Wales; and in 1835, Sedgwick proposed the name "Cambrian" for a series of rocks in Wales, supposed by him to be without life. A little later, about 1837, Murchison proposed the name "Silurian" for another and a higher series, which he thought contained the earliest forms of animal life. A conflict soon arose between the adherents of the two systems. Murchison extended his Silurian downward as fossils were found at lower and lower horizons, against the vigorous opposition of Sedgwick. It was not until the characters of the fossils were studied that a definite understanding was reached as to the lower limit of the Silurian. These studies were made by Barrande in Bohemia. He announced, in 1846, his discovery of trilobites with peculiar features. To the fauna, as a whole, he gave the name of "Primordial." He pointed out various differences between it and the English Silurian, calling this last the "Second fauna." Barrande did not know at this time of Emmons's name "Taconic," nor had he heard of the fossils that had been described. Had he known of the work of Emmons, he would doubtless have adopted the name Taconic, instead of proposing Primordial.

Continued investigation in North America soon brought new facts to light. Owen, in 1847, reported many fossiliferous beds in the upper Mississippi Valley that he compared with the Potsdam of New York. Roemer found in Texas, in 1848, fossils similar to those of Owen; and when Barrande, in 1853, heard of and saw the fossils from these two localities, he announced that they belonged to his Primordial period. In 1856, Prof. W. B. Rogers called the attention of the Boston Society of Natural History to the discovery of a trilobite in the slates of Braintree, near Boston. He thought it the same species as that described in 1834 by Dr. Green as *Paradoxides harlani*, and noted, at the same time, the resemblance it bore to a species of the genus from Bohemia, called by Barrande, *P. spinosus*. When he sent a photograph of the new specimen to Barrande, this authority, too, concluded the two specimens were identical. Thus the presence in America of the "primordial" fauna of Barrande was at last firmly established, and the work to come was the filling in of the outlines, closing the gaps and bringing order out of the chaos that had before reigned.

One of the most intricate problems to be settled was that relating to the age of certain rocks in northern Vermont, occurring near the town of Georgia. It was in this region that the fossils described by Emmons had been found. Their age had been variously estimated as Medina, Hudson River and Potsdam (see table of formations on a previous page), but, without going into the details of the controversy, it must suffice to say that it was at last decided that these "Georgia slates" were older than the Potsdam, but not as old as the Braintree, Mass., beds, in which *Paradoxides* had been found. Prof. Hall had established the genus *Olenellus* to include the Vermont trilobites, and the idea prevailed that this genus succeeded *Paradoxides* in time. It was in 1868 that the first reference was made of the Potsdam rocks to the top of the Primordial period, instead of to the base of the Silurian where they had previously been placed. So that at this time the Braintree beds were supposed to contain the oldest fossils on the globe.

Meanwhile, geologists had been studying the fauna in rocks occurring about St. John, New Brunswick. Noting the resemblance the trilobites there bore to those from Braintree, they concluded the two deposits were of the same age. In Canada, Logan, in 1864, taking cognizance of all the discoveries in New York, Vermont, Massachusetts, New Brunswick and Newfoundland, published a scheme of classification which, for twenty-four years, perpetuated an error. This scheme in its lower portion is as follows:

(3) *Upper Potsdam*, including the rocks of the upper Mississippi Valley, northern New York and adjacent parts of Canada.

(2) *Lower Potsdam*, including the rocks of Georgia, Vermont, and some of Newfoundland.

(1) *St. John Group*, including the rocks at Braintree, Mass., St. John, New Brunswick, and St. John's, Newfoundland.

This view of the succession of the oldest fossil-bearings rocks of North America was held until 1888, except that the three divisions were called respectively, (3) Upper Cambrian, (2) Middle Cambrian, and (1) Lower Cambrian. Of these divisions the Upper was also called the *Dikellocephalus zone*, the Middle the *Olenellus zone*, and the Lower the *Paradoxides zone*, from the three genera of trilobites confined to the rocks of each terrane.

(*To be continued.*)